Annex J

(informative)

AIM EXPRESS listing

This annex provides a listing of the complete EXPRESS schema specified in annex A of this part of ISO 10303 without comments or other explanatory text. It also provides a listing of the EXPRESS entity names and corresponding short names as specified in annex B of this part of ISO 10303.

The content of this annex is available in computer-interpretable form and can be found at the following URLs:

- Short names: http://www.mel.nist.gov/div826/subject/apde/snr/

- EXPRESS: http://www.mel.nist.gov/step/parts/part227e2/cd1/

If there is difficulty accessing these sites contact ISO Central Secretariat or contact the ISO TC 184/SC4 Secretariat directly at: sc4sec@cme.nist.gov.

NOTE The information provided in computer-interpretable form at the above URLs is informative. The information that is contained in the body of this part of ISO 10303 is normative.

Annex K

(informative)

Application protocol usage guide

This annex provides an explanation and guidance on the usage of this part of ISO 10303. The annex is divided into sections; each section addresses a different important or high-value topic or capability of this part of ISO 10303.

NOTE The material in this annex differs from that in the Technical Discussion, annex L, in that the purpose of the material presented herein is to explain how to use this part of ISO 10303 in several important areas.

The guidelines provided in this annex are suggestions for best usage of this part of ISO 10303. They shall be interpreted by users of this standard as recommendations rather than as requirements.

NOTE A detailed Usage Guide for this part of ISO 10303 for Ship Piping has been published as a separate document [15].

K.1 Identifiers

Identifiers are alphanumeric labels that uniquely identify an instance of an entity within a given data population. The data population may be either (1) the boundaries of an exchanged data file, (2) the boundaries of a particular project, or (3) the life-cycle of a plant. The guidelines provided herein fully address (1), but only partially address (2) and (3) since the actions and policies involved in a design project or the life-cycle of a process plant are beyond the scope of this part of ISO 10303. These guidelines do not address the instance identifiers required by ISO 10303-21.

Identifiers as used within this part of ISO 10303 fall into two classes. One class are application object identifiers that are specified in Clause 4 and the ARM. These application object identifiers and their corresponding AIM identifier and recommended usage or interpretation are listed in table K.1. The second class are those that are specified in the AIM. These AIM identifiers and their corresponding ARM uses and recommended usages or interpretations are listed in table K.2.

All application object identifiers shall be unique within the context of an exchange file and should be unique within both a project and through the life-cycle usage of a process plant. The identifier may correspond to a product data identifier used in other representations of product data, such as a part number on a drawing. If the application object identifier does not correspond to a real world identifier, an identifier shall be fabricated based on policies and procedures of the particular project or plant. This identifier is more than a system generated identifier in that it should have persistence over time as the data is used and exchanged.

Table K.1 - Application object identifiers

Application object identifier	AIM identifier	Recommended usage or interpretation
Access_opening_id	shape_aspect.name	This attribute differentiates one Hvac_access_opening on an Hvac_component from another.
Branch_sequence_id	shape_aspect_relationship.name	This specifies an alphanumeric identifier that indicates the order that branches extend from the main Hvac_section_segment or th emain Piping_system_line_segment.
Building_id	representation	This specifies a unique number used to identify the building.
Catalogue_id	document.id	This corresponds to a volume number or issue number or a date that uniquely identifies a published (i.e,. configuration controlled) version of a catalogue. This value should be unique across the project and plant life cycle.
Change_id	action.name	This corresponds to designations such as Engineering Change Notice (ECN) numbers and similar codes used to identify, track, and control changes made to the design data. It is strongly recommended that it be unique throughout the life cycle of the plant.
Change_item_-id	change_item_id_-assignment (name_-assignment.name)	Since a Change_item is not a new thing, the Change_-item_id is an extra identifier associated with something that already exists. It does not correspond to any real world identifier. It is strongly recommended that the value of the attribute change_item_id_assignment (name_assignment.name) be unique throughout the life cycle of the plant.
Connecting_portion_id	identification_assignment.assigned_id	This specifies a descriptive identification of the area of the connection that is being inspected.
Connection_id	shape_aspect.name	A connection is a shape_aspect of the assembly that contains the connection. There may or may not be a real world identifier that corresponds to a particular connection in a plant system. If such an identifier does not exist, a value shall be fabricated to uniquely identify each connection.
Control_loop_-id	product.id	This corresponds to a real world control loop number or designation. It should be unique within a project and plant life cycle.
Design_-project_id	organization.id	This corresponds to a project code or some other identifier other than project number (a designation that maps to organization.description). This may be fabricated. It should be unique within the plant life cycle.

Table K.1 - Application object identifiers - (continued)

Application object identifier	AIM identifier	Recommended usage or interpretation
Document_id	document.id	This specifies a unique identification for the Document.
Element_id	representation_-item.name	This does not correspond to any real world identifier. The closest real world equivalent would be the id of a geometric element in a CAD system. It may be considered a system identifier used to differentiate among geometric elements. A value may be fabricated if there is a need to uniquely identify a geometric element in a scope beyond a geometric model file.
Flow_control_device_id	product.id	This specifies a unique identifier for each of the inline control devices.
Hvac_section_id	product_definition.id	This specifies a unique identifier for the Hvac_section_segment.
Hvac_specification_id	document.id	This attribute specifies a designation that differentiates one Hvac_specification from another.
Instrument_id	product.id	This attribute specifies the unique identifier for each Hvac_instrument.
Interference_id	product_definition_-relationship.name	If two plant_items clash, there is a product_definition_-relationship defined between them. This does not correspond to any real world identifier. It should be fabricated, but there is probably little need for it to be unique across a project or plant life cycle.
Line_to_line_-connection_id	shape_aspect_-relationship.name	This does not correspond to any real world identifier. It may be considered a system identifier used to differentiate among connections between line segments.
Location_id	representation_-item.name	A plant_item is located in a plant with a mapped_item as a representation. Hence, representation_item is used and location_id maps to representation_item.name. This does not correspond to any real world identifier.
Material_-requirement_id	product.id	This is the identifier of the material required by or for a plant_item. The material is considered as a product. It corresponds to a real world designation, but is not equivalent to a material specification identifier. It may be the part number of raw stock or a chemical designation like H_2O.
Material_-specification_id	document.id	This corresponds to the identifier of a material specification or manual, e.g., ASTM A403.
Operating_-case_id	property_-definition_-relationship.name	This is a fabricated identifier that does not correspond to any real-world identifier. It is used only to differentiate among service_operating_cases.
Piping_-specification_id	document.id	This corresponds to the identifying designation of a piping specification. It is strongly recommended that it be unique throughout the project and plant life cycle.

Table K.1 - Application object identifiers - (continued)		
Application object identifier	**AIM identifier**	**Recommended usage or interpretation**
Piping_-system_line_id	product_definition.id	This is a fabricated designation that should have a one-to-one correspondence with the line number. It is used in addition to line number because line numbers sometimes have minor variations, e.g., Line 111a, Line 111-1.
Plant_id	product.id	This corresponds to the identifying designation given to a plant, if such a designation exists. If not, a value may be fabricated. There should be a one-to-one correspondence between this value and the plant name.
Plant_item_id	product_definition.id	Most often this will be interpreted as a Part Number. The specific interpretation depends on usage: Functional Design View - Plant Item Definition This value must be fabricated. There is no real-world equivalent in common use. Functional Design View - Plant Item Instance This value must be fabricated. It may be associated with zero or one TAG Number. Physical Design View - Plant Item Definition This value may be fabricated, but it typically corresponds to a Part Number. Physical Design View - Plant Item Instance This value may be fabricated, but it corresponds to the use of a part in a design (i.e., instance number). It may be associated with zero or one serial number.
Plant_item_-connector_id	shape_aspect.name	A connector is a shape_aspect of a plant_item. There may or may not be a real world identifier that corresponds to a particular connector of a plant system. If such an identifier does not exist, a value shall be fabricated to uniquely identify each connector.
Plant_process_capability_id	property_-definition.name	This does not correspond to any real world identifier. It may be considered a system identifier used to differentiate among process capabilities.
Plant_system_-id	product.id	This corresponds to a unique designation given to a system within a plant. It is strongly recommended that it be unique within a project and throughout the plant life cycle.
Reference_-geometry_id	representation_-item.name	This does not correspond to any real world identifier. It may be considered a system identifier used to differentiate among reference geometry.

Table K.1 - Application object identifiers - (continued)

Application object identifier	AIM identifier	Recommended usage or interpretation
Section_to_section_connection_id	shape_aspect_relationship.name	This specifies a unique identifier of the connection between two Hvac_section_segments.
Segment_id	product_definition.id	This is a fabricated designation that may or may not correspond to a real world designation. It is used principally to differentiate between segments of a line.
Selection_id	document_usage_-constraint. subject_element	This corresponds to a table number, chapter number, line or row number, section number, or some other designation that identifies a particular portion of a material specification or manual.
Set_id	product_definition.id	This specifies a unique identifier for a Bolt_and_nut_set or a Clamp_set.
Shape_id	property_-definition.name	Shape is a property of a plant_item. This does not correspond to any real world identifier, though it may be interpreted as a unique file name or drawing number for different representations of the shape of a plant_-item.
Site_feature_id	property_-definition.name	This may or may not correspond to a real world identifier. It may be fabricated to differentiate among site features. A site feature is a property of a site.
Site_id	characterized_-object.name	This corresponds to designations that identify a site or plot of land. Examples include municipal plot or tract designations or GIS descriptions. Sites cannot be defined unless they are associated with a plant. The value may be fabricated for a particular project or plant life cycle.
Source_id	external_source.source_id	This specifies a unique identification of the external origin of the Document.
Splitter_id	shape_aspect.name	This attribute specifies a unique identifier for the Splitter.
Stream_-design_id	characterized_-object.name	This may or may not correspond to a real world identifier. It uniquely identifies the definition of particular stream states. A value may be fabricated is there is a need to uniquely identify a stream state (i.e., design case) across a project or plant life cycle.
Subset_id	document_-relationship.name	This corresponds to a subsection reference or other designation that identifies a portion of a material specification.
Supplier_id	organization.id	This corresponds to a designation that uniquely identifies a supplier to a project or plant life cycle.
Support_-constraint_id	representation.name	This does not correspond to any real world identifier. It may be considered a system identifier used to differentiate among support components.

1327

<table>
<tr><td colspan="3" align="center">**Table K.1 - Application object identifiers - (continued)**</td></tr>
<tr><td>**Application object identifier**</td><td>**AIM identifier**</td><td>**Recommended usage or interpretation**</td></tr>
<tr><td>Termination_id</td><td>shape_aspect.name</td><td>This does not correspond to any real world identifier. It may be considered a system identifier used to differentiate among terminations used to connect line segments.</td></tr>
<tr><td>Version_id</td><td>identification_assignment.assigned_id</td><td>This specifies a unique identification of a revision of a particular Document.</td></tr>
<tr><td>Weld_id</td><td>identification_assignment.assigned_id</td><td>This specifies an identification of the weld point at which the inspection is being made.</td></tr>
</table>

Table K.2 - AIM identifiers

AIM identifier	ARM uses	Recommended usage or interpretation
document.id	catalogue_id piping_- specification_id material_- specification_id	As mapped.
organization.id	Design_project_id Supplier_id	As mapped.
person.id	none	Although individuals are not explicitly identified in the ARM, attributes such as approval.approver require the person entity. A unique value should be fabricated to differentiate among persons.
product.id	Control_loop_id Plant_id Plant_system_id Material_- requirement_id	As mapped.
product_- definition.id	Plant_item_id Piping_system_- line_id Segment_id	As mapped.
product_- definition_- formation.id	None	This may or may not correspond to a real world identifier. It is used to differentiate among versions of product design.
product_- definition_- formation_- relationship.id	None	This does not correspond to a real world identifier. A value shall be fabricated to differentiate among product_definition_formation_relationships.
product_- definition_- relationship.id	None	This does not correspond to a real world identifier. A value shall be fabricated to differentiate among product_definition_formation_relationships.
representation_- context.context_ identifier	None	This does not correspond to a real world identifier. A value shall be fabricated that is unique to a specific type of context and differentiates among local coordinate systems.
versioned_- action_request.id	None	This may or may not correspond to a real world identifier. If it does, it may correspond to an identifier found on a change request.

K.2 Units

Most measures will be expressed in terms of SI units. For units such as inches, instances of conversion_based_unit must be used. Figure K.1 contains a fragment of the EXPRESS-G for the
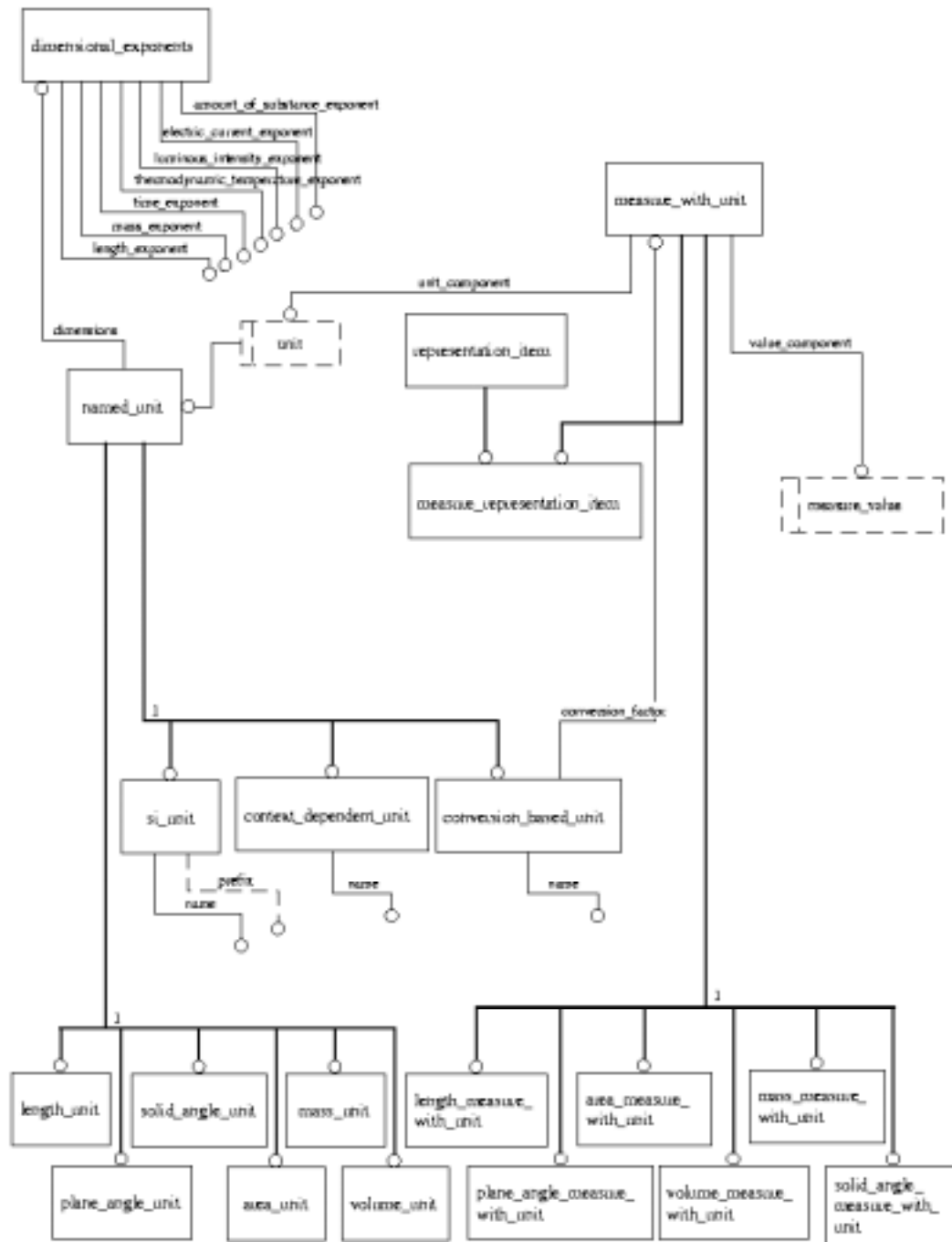
1329

Figure K.1 - Fragment of measure_schema in EXPRESS-G

measure schema (see ISO 10303-41). Compare the EXPRESS with the following fragment of an ISO 10303-21 data file:

```
/* length dimension's exponent = 1 */
#22=DIMENSIONAL_EXPONENTS(1.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0);
#200=(LENGTH_UNIT()NAMED_UNIT(#22)SI_UNIT(.MILLI.,.METRE.));
/* Inches unit - length measure*/
/* conversion factor from mm to inches: 1 inch = 25.4 mm */
#201=LENGTH_MEASURE_WITH_UNIT(LENGTH_MEASURE(25.4),#200);
/* specifies length unit - based on conversion from millimeters */
#202=(CONVERSION_BASED_UNIT('inches',#201)LENGTH_UNIT()NAMED_UNIT
(#22));
```

The units that the conversion is based upon are millimetres. The units are represented by instance #200. This instance is:

— a named unit with dimensional exponents of length;
— a length_unit; and
— a SI unit: millimetre.

Instance #201 represents the conversion of millimetre values to another value. The conversion factor is 25.4, meaning that millimetres are multiplied by 25.4 to yield another value.

Instance #202 applies the name of "inches" to the converted value. It is also a named unit (with dimensional exponents of length) and a length unit.

Note that these data are not a *converted* value, but rather are the specification of a unit (inches in #202) derived from a known SI unit. Measures that use inches would reference #202. For example, the datum:

```
/* Nominal size = 0.5" */
#100=(LENGTH_MEASURE_WITH_UNIT()
MEASURE_REPRESENTATION_ITEM()
MEASURE_WITH_UNIT(LENGTH_MEASURE(0.5),#202)
REPRESENTATION_ITEM(''));
```

Represents a nominal size of one-half inch because it references #202 as the unit component.

Axis_placement

Position and orientation of objects within a geometric coordinate system are either inherently part of the geometric definition of the object or are defined through a transformation mechanism. The position and orientation mechanisms used for transformation in ISO 10303-42 are cartesian_-points and the "placement" entities. EXPRESS definitions of the 3D versions of these placement entities are:

```
ENTITY placement
  SUPERTYPE OF (ONEOF(axis1_placement,axis2_placement_2d,axis2_placement_3d))
  SUBTYPE OF (geometric_representation_item);
  location : cartesian_point;
END_ENTITY;
```

```
ENTITY axis2_placement_3d
  SUBTYPE OF (placement);
  axis        : OPTIONAL direction;
  ref_direction : OPTIONAL direction;
DERIVE
  p           : LIST [3:3] OF direction := build_axes(axis,ref_direction);
WHERE
  WR1: SELF\placement.location.dim = 3;
  WR2: (NOT (EXISTS (axis))) OR (axis.dim = 3);
  WR3: (NOT (EXISTS (ref_direction))) OR (ref_direction.dim = 3);
  WR4: (NOT (EXISTS (axis))) OR (NOT (EXISTS (ref_direction))) OR
       (cross_product(axis,ref_direction).magnitude > 0.0);
END_ENTITY;
```

The entity axis2_placement_3d is location point (SELF\placement.location.dim) and a set of orthogonal axes defined by the derived attribute axis2_placement_3d.p. The derivation uses the Z axis specified by the attribute axis2_placement_3d.axis and, optionally, an approximate X axis specified by the axis2_placement_3d.ref_direction to construct a set of orthogonal axes. The following fragment of an ISO 10303-21 data file illustrates a set of axes at the origin:

```
#20=CARTESIAN_POINT('origin point',(0.0, 0.0, 0.0));
#40=DIRECTION('X',(1.0,0.0,0.0));
#41=DIRECTION('Y',(0.0,1.0,0.0));
#42=DIRECTION('Z',(0.0,0.0,1.0));
#66=AXIS2_PLACEMENT_3D('generic origin',#20,#42,#40);
```

K.4 describes how axis2_placements are used for positioning and orientation of shape representations.

K.3 Mapped_item and representation_item

Figure K.2 illustrates how the shape representation of one object is positioned and oriented in another shape representation. The positioning is accomplished by "superimposing" an axis2_placement_3d (A3: (X3, Y3, Z3)) in one shape representation (SR-B) onto another axis2_placement_3d (A2: (X2, Y2, Z2)) in a different shape representation (SR-C). Since A2 is positioned relative to all the geometric elements in SR-C, placing and orienting A3 so that it corresponds to A2 in SR-C will produce the effect of positioning SR-B in SR-C. This is accomplished with mapped_item and representation_item.

The EXPRESS for mapped_item and representation_map are as follows:

```
ENTITY mapped_item
  SUBTYPE OF (representation_item);
    mapping_source : representation_map;
    mapping_target : representation_item;
  WHERE
    wr1: acyclic_mapped_representation(using_representations(SELF),
        [SELF]);
END_ENTITY; -- mapped_item
```
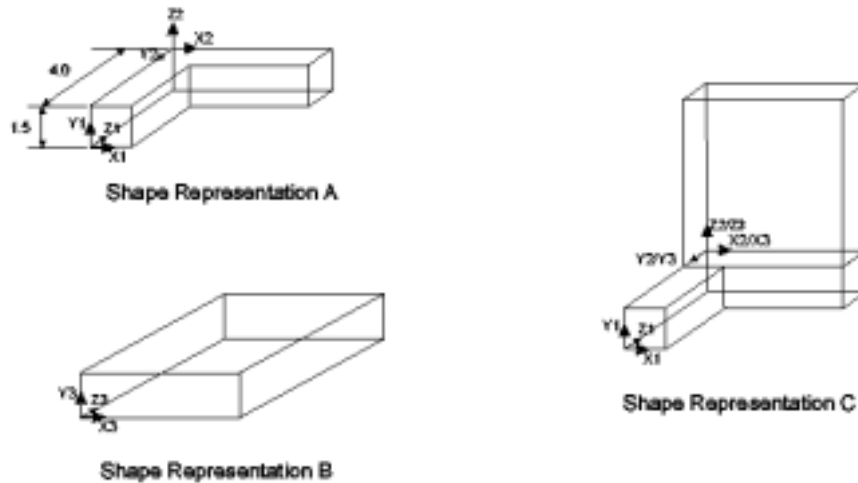
1332

Figure K.2 - Positioning of shape representations

```
ENTITY representation_map;
   mapping_origin      : representation_item;
   mapped_representation : representation;
 INVERSE
   map_usage : SET [1:?] OF mapped_item FOR mapping_source;
 WHERE
   wr1: item_in_context(SELF.mapping_origin,SELF.mapped_representation.
        context_of_items);
END_ENTITY; -- representation_map
```
Using the data from above plus unit information:

```
#1=GLOBAL_UNIT_ASSIGNED_CONTEXT('contxtid:c1','contxttype: length',(#2));
#2=(LENGTH_UNIT()NAMED_UNIT(#3)SI_UNIT(.MILLI.,.METRE.));
#3=DIMENSIONAL_EXPONENTS(1.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0);
#20=CARTESIAN_POINT('origin point',(0.0, 0.0, 0.0));
#40=DIRECTION('X',(1.0,0.0,0.0));
#41=DIRECTION('Y',(0.0,1.0,0.0));
#42=DIRECTION('Z',(0.0,0.0,1.0));
#66=AXIS2_PLACEMENT_3D('generic origin',#20,#42,#40);
```

The shape_representation of A from figure K.2 is:

```
#100=CARTESIAN_POINT('location of block B',(0.0, 1.5, 4.0));
#101=AXIS2_PLACEMENT_3D('orientation of block B',#100,#41,#40);
#105=SHAPE_REPRESENTATION('shape representation A',(#66, #101, <shape of L-
shape block>),#1);
```

Things to note about these data include:

— cartesian_point #100 as used in axis2_placement_3d #101 (A2) is the position of A2 and, thus, of shape representation B (SR-B).

— the Z axis of the axis2_placement_3d #101 *points in the Y direction* within shape representation A. This is very significant because by aligning the *Z axes* of A3 in shape representation B and A2 in shape representation A, the desired orientation of shape representation B in shape representation C is achieved.

— for simplicity, the explicit geometry of the L-shaped block is not included in shape representation #105.

The shape representation of B is:

> #110=SHAPE_REPRESENTATION('shape   representation   B',(#66,   <shape   of block>),#1);

Things to note about this datum include:

— the origin axes of both shape representation A #105 and shape representation B #110 are the same. This does not present a conflict because the same data is simply used differently, i.e., used in different contexts. The shape representation contexts of both of the representations are different. No assumption shall be made concerning the relationship of these axes unless they are made to be part of the same context.

The shape representation of C requires the use of representation_item and mapped_item.

> #120=REPRESENTATION_MAP(#66,#110);
> #121=MAPPED_ITEM('positioned shape B in C',#120,#101);
> #122=SHAPE_REPRESENTATION('shape   representation   C',(<shape   of   L-shaped block>, #121),#1);

Things to note about these data include:

— representation_map #120 specifies the base mapping information: the mapped_representation #110 and the mapping_origin, #66. The mapping_origin is the element *in the representation* of the mapped_representation that is used to position and orient the shape. Most often this will be a set of axes at the origin, but it may be other things as well.

— mapped_item #121 specifies the mapping transformation. The mapping_source is the representation_map to be transformed. The mapping_target is the *destination* of the transformation. The representation_map is moved such that the axis2_placement_3d.location of the mapping_origin is at, on top of, or corresponds with the axis2_placement_3d.location of the mapped_item.mapping_target. Similarly, the representation_map is rotated such that the axes of the mapping_origin are aligned with the axes of the mapping_item.mapping_target.

— the shape representation C consists of the L-shaped block, that is the same shape representation element used for shape representation A, and the mapped_item #121, that is the positioned shape of shape representation B.

This is just one approach for positioning the shape representation of objects within other shape representations. It is strongly recommended that axis2_placement_3d objects be used for the representation_map.mapping_origin and mapped_item.mapping_target.

K.4 Interfaces to ISO 13584 and ISO 10303-221

This part of ISO 10303 may be used in conjunction with ISO 13584 [13] to identify catalogue items (Parts Libraries) and classifications, and with ISO 10303-221, annex M [3], to classify plant items, plants, plant systems, and connectors. With respect to this part of ISO 10303, both ISO 13584 [13] and ISO 10303-221 are considered as external sources and are referenced using known_source (see). A known_source is both an external_source and a pre_defined_item (see). It is used for referencing ISO 13584 because ISO 13584 is an external source of information with respect to this part of ISO 10303 and is also pre-defined with respect to this part of ISO 10303.

ISO 10303-221 is referenced only as an external source. It is not pre-defined with respect to this part of ISO 10303 for reasons that are not explained here because they are not germaine to the annex K or to this part of ISO 10303.

In the following explanation, the only difference between a reference to ISO 13584 and ISO 10303-221 is that a reference to ISO 13584 is a complex instance consisting of external_source, known_source, and pre_defined_item and a reference to ISO 10303-221 is a simple instance of external_source. Pre_defined_item and known_source are used to explicitly list the names of the allowable external sources in this part of ISO 10303.

The EXPRESS code for the external source is presented below. Figure K.3 shows the EXPRESS-G version.
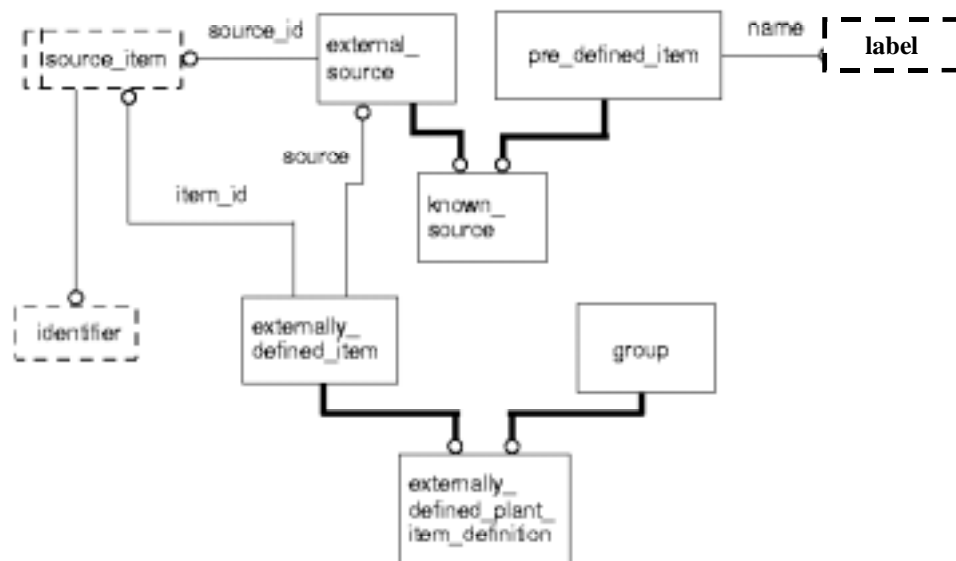

Figure K.3 - Known_source for externally defined items

```
ENTITY  external_source;
    source_id : source_item;
 END_ENTITY; -- external_source

 ENTITY  pre_defined_item;
    name : label;
 END_ENTITY; -- pre_defined_item

 ENTITY  known_source
  SUBTYPE OF (external_source, pre_defined_item);
  WHERE
   wr1: SELF\pre_defined_item.name IN ['ISO 13584 Dictionary',
         'ISO 13584 Parts Library'];
 END_ENTITY; -- known_source

 TYPE  source_item = SELECT
  (identifier);
 END_TYPE; -- source_item

 ENTITY  externally_defined_item;
    item_id : source_item;
    source  : external_source;
 END_ENTITY; -- externally_defined_item


 ENTITY  externally_defined_plant_item_definition
   SUBTYPE OF (product_definition, externally_defined_item);
 END_ENTITY; -- externally_defined_plant_item_definition
```

For plant items that are defined externally to the exchange file (e.g., as in a reference to a part in a part library or to a catalogue item), the EXPRESS would be used as shown in table K.3.

Table K.3 - EXPRESS for externally defined plant items

EXPRESS	Explanation	Example
known_source/-predefined_item.name	Provides the name of the known external source.	Example: 'ISO 13584 Parts Library'
known_source/external_-source.source_id	Identifies the external source.	Example: 'ISO 13584-21:1996'
known_source	The complex instance that represents the external source.	Example: #10=(known_source() pre_defined_item('ISO 13584 Parts Library') external_source('ISO 13584-21:1996'))
externally_defined_item.-source	References the known_-source that contains the externally defined item.	Example: references ("points at") the known_source for ISO 13584, #10 above.
externally_defined_-item.item_id	Identifies the item within the known_source.	Example: 'Reciprocating Pump Model 100'
externally_defined_item/-product_definition/-externally_defined_plant_-item_definition	The complex instance that represents an externally defined item in an exchange file using the AP 227 AIM.	Example: a reference to a catalogue item within a use of this part of ISO 10303.

Externally defined classifications follow the same approach substituting group for product_-definition:
```
 ENTITY  externally_defined_classification
   SUBTYPE OF (group, externally_defined_item);
   WHERE
    wr1: SIZEOF(QUERY ( ca <* QUERY ( ga <* USEDIN(SELF,
     'PLANT_SPATIAL_CONFIGURATION.GROUP_ASSIGNMENT.ASSIGNED_GROUP')
     | ('PLANT_SPATIAL_CONFIGURATION.CLASSIFICATION_ASSIGNMENT'
     IN TYPEOF(ga)) ) | (NOT (SIZEOF(QUERY ( it <* ca.items | (
     NOT ((SIZEOF(TYPEOF(it) * [
     'PLANT_SPATIAL_CONFIGURATION.ELECTRICAL_SYSTEM',
     'PLANT_SPATIAL_CONFIGURATION.DUCTING_SYSTEM',

'PLANT_SPATIAL_CONFIGURATION.INSTRUMENTATION_AND_CONTROL_SYSTEM'
',
     'PLANT_SPATIAL_CONFIGURATION.PIPING_SYSTEM',
     'PLANT_SPATIAL_CONFIGURATION.PLANT',
     'PLANT_SPATIAL_CONFIGURATION.PLANT_ITEM_CONNECTOR',
     'PLANT_SPATIAL_CONFIGURATION.PIPING_COMPONENT_DEFINITION',
```

```
    'PLANT_SPATIAL_CONFIGURATION.STRUCTURAL_SYSTEM']) = 1) OR ((
    'PLANT_SPATIAL_CONFIGURATION.PRODUCT_DEFINITION' IN TYPEOF(
    it)) AND (SIZEOF(QUERY ( pc <* it.formation.of_product.
    frame_of_reference | (pc.discipline_type = 'process plant') ))
    = 1)))) )) = 0)) )) = 0;
  END_ENTITY; -- externally_defined_classification
```

Figure K.3 shows the EXPRESS-G for the external classification.

K.5 Precedence of geometric descriptions

There are three principal methods for specifying the geometric shape of a plant item:

— explicit geometric representation;

— parametric representation;

— catalogue item identification.

A explicit geometric representation is the wireframe, b-rep, or csg geometry (or combination thereof) that is specified as the shape of a plant item. Parametric representation may be used for fittings. This representation specifies values for certain dimensional parameters of common fittings like elbows and reducers. A catalogue item identification uses neither explicit geometry or parametric values, but rather identifies a catalogue item that is commonly understood between partners in a data exchange. In an exchange using this part of ISO 10303, all three representations may be simultaneously used. This leads to a question of precedence among the representations, particularly if there is a conflict.

There is no absolute ordering with respect to which of these representations take precedence. Rather precedence depends on the use of the geometric representation. For example, for CAD display purposes, the explicit geometry, if present, should take precedence over the parametric representation or catalogue identification. Parametric representations should take precedence over explicit geometry when connectivity checks of mating conditions are performed.

In general, since a catalogue item identification would, presumably, identify a specific plant item design that is commonly understood between partners, the shape indicated or determined by the catalogue item identification, if present, should take precedence over the explicit geometry (since it subject to errors) and the parametric representation (because it is an approximate representation of the shape.)

K.6 Lines and line segments

The purpose of this part of ISO 10303 is not to exchange piping line information equivalent to that of a P&ID, but only that subset of information necessary for piping design. In this part of ISO 10303, piping lines specify the logical connectivity and some of the characteristics of process streams. The piping lines (piping_system_lines) are a network of logical nodes and arcs analogous to those found on a P&ID. Figure K.4 (a) illustrates piping lines as a network of nodes and arcs. These networks are purely logical and exist in the figure solely for the purpose of illustration. There are no geometric representations intended or implied.
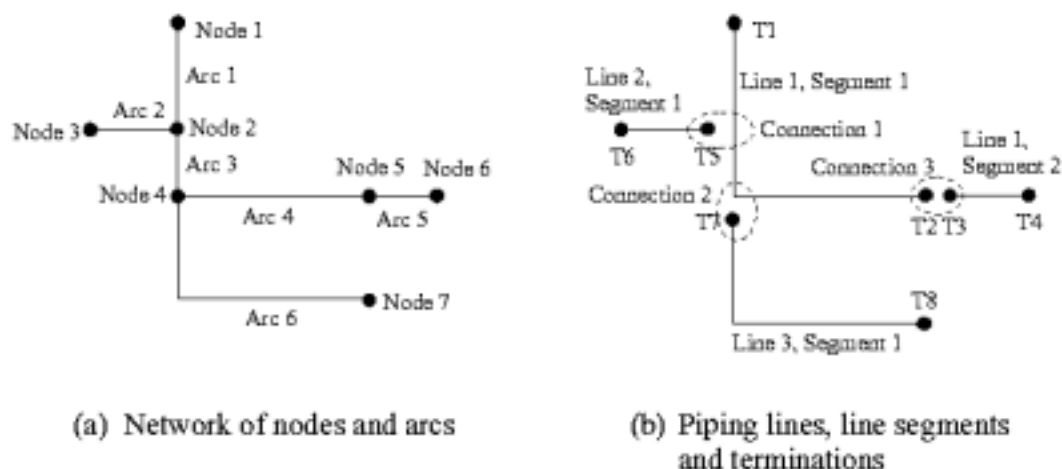
(a) Network of nodes and arcs

(b) Piping lines, line segments and terminations

Figure K.4 - Piping line network

A piping system line, typically identified with a line number, is composed of a set of connected piping system line segments. Other piping system lines may branch from a given line, forming a piping network. In general, a piping system line segment is distinguished by the fact that the process stream has uniform characteristics over the length of the segment.

Nodes exist at:

— equipment inlets and outlets;

— line inlets and outlets (e.g., drains and vents);

— significant changes in the characteristics of the process stream;

— junctions.

Equipment and line inlets and outlets are natural nodes for a piping system line. A significant change in the characteristics of the process stream also merits a node. Reducers, for example, correspond to a single segment with nodes at each end.

Junctions are divergences or confluences of a single line. Branches are treated a little differently in this part of ISO 10303 when compared to ISO 10303-221 [3]. Since nodes represent a significant change in stream conditions, there many not be a node at a minor branch. In this case, the branch line segment connects to the main line at some point other than at a termination node. Figure K.4 (b) illustrates this. Line 2 and line 3 (each consisting of a single line segment) are branches from line 1. They are connected at line_branch_connections.

Figure K.4 (b) also illustrates connections between piping system line segments. The three dotted ellipses represent two kinds of connections. Each line segment has a pair of terminations. Line branch connections, as described above, are connections between a termination on a branch and the line segment that it branches from. Connections between line segments, as shown in connection 3, are two or more segment terminations.

Annex L
(informative)

Technical discussions

This annex provides discussions of certain technical aspects of this part of ISO 10303 for the purpose of clarifying those aspects.

NOTE The material in this annex differs from that in the Usage Guide, annex K, in that the purpose of the material here is to explain technical aspects of the design of this part of ISO 10303 that may be confusing or unclear as a result of the documentation format.

L.1 Fitting parameters and nominal size

The shape of fitting piping components may be defined parametrically in this part of ISO 10303. There are three aspects to this parametric definition:

— Fitting parameters;

— Connector parameters;

— Piping size description.

Fitting parameters are attributes of fitting application objects, such as an Elbow, defined in 4.2. An Elbow is defined by the attributes:

— centre_to_end_1_length;

— centre_to_end_2_length;

— centreline_radius;

— end_1_connector;

— end_2_connector;

— sweep_angle;

— type.

Centre_to_end_1_length, centre_to_end_2_length, centreline_radius, and sweep_angle are fitting parameters. End_1_connector and end_2_connector are connectors (or references to connectors) that have parameters of their own depending on the end type (e.g., socket, flange). Type is a label that classifies or describes the Elbow.

Each connector of the Elbow may have its own set of parameters. If one end of the Elbow was flanged, the parameters at the flanged end would be:

— flange_inside_diameter;

— flange_outside_diameter;

— flange_thickness;

— raised_face_diameter;

— raised_face_height;

— ring_bottom_radius;

— ring_diameter;

— ring_width.

If the other end of the elbow was a socket, the parameters at the socket end would be:

— depth;

— hub_inside_diameter;

— hub_length;

— hub_outside_diameter.

For piping components, the specification of a nominal size is a very important and very common approach to specifying the shape of the component. This is done with the piping_size_description application object. The attributes for this object are:

— dimensional_standard;

— ovality_allowance.

The four kinds of piping size descriptions are inside_and_thickness, outside_and_thickness, pressure_class, and schedule. The attributes for the inside_and_thickness object are:

— inside_diameter;

— thickness.

The attributes for the outside_and_thickness object are:

— outside_diameter;

— thickness.

The attributes for the pressure_class object are:

— nominal_size;

— pressure_rating.

The attributes for the schedule object are:

— nominal_size;

— pipe_schedule.

All of the attributes of piping size description and the four kinds of piping size descriptions are parameters, except for dimensional standard and pipe schedule, that are references to documents. It is important to note that nominal size, as used in this part of ISO 10303, has the same meaning as the term used in process plant industry. It does not denote an actual dimension of a component (as does "outside diameter"), but rather is an approximation or description of the size of the component.

A piping size description may be applied to a piping component in its entirety or to an individual connector on a piping component. Therefore, conflicts may arise between the specification of a piping size description and the fitting or connector parameters. This part of ISO 10303 does not specify a precedence among these representations in the case of conflicts. Precedence needs to be resolved on a case-by-case or project-wide basis.

L.2 Value range, family definitions and range values

Dimensions, fitting parameters, and nominal sizes are typically associated with a single value.

EXAMPLE   Single values for weld neck flange attributes are:

— hub through length: 5 inches
— hub weld point diameter: 3 inches
— flange inside diameter: 1.5 inches
— flange outside diameter: 8 inches
— flange thickness: 0.75 inches

There are occasions, however, when a family of parts needs to be described, such as in a piping specification.

EXAMPLE   A range of values for the attributes of a family of weld neck flanges are:

— hub through length: 5 inches
— hub weld point diameter: 3 inches
— flange inside diameter: 1 to 2 inches
— flange outside diameter: 6 to 8 inches
— flange thickness: 0.75 to 1.25 inches

This part of ISO 10303 supports the specification of a range of values (i.e., a "value range") for a given dimension, parameter, or nominal size for the purpose of defining a family of parts. This is done by specifying two dimensional values for a given parameter. One dimension has a representation_item.name with a value of "minimum_<parameter name>" (e.g., "minimum_flange_inside_diameter") and the other has a representation_item.name with a value of "maximum_<parameter name>".

A separate but related concept is the notion of range value. A range value, like the range of values, has a minimum and maximum value. It does not, however, indicate a family of parts. It indicates a parameter that may actually vary on the physical part. A range value is not a dimension that can vary within a prescribed tolerance.

EXAMPLE   Insulation may be described as 6 inches thick, but in reality it may be 5-7 inches thick. Range values permit this to be specified.

In 4.2, the attributes that use range values are differentiated from the attributes that use value ranges by a explanatory note that follows the attribute definition.

L.3 Piping specifications

As noted in clause 1, this part of ISO 10303 is intended for the exchange of references to piping specifications, not the exchange of the specification itself. However, since piping specifications are important to piping design, some aspects of piping specifications are included. The piping_specification.owner is the individual or organization that is responsible for its content (either as a creator or maintainer). The piping_specification.name is whatever useful designation the owner applies to it. The piping_specification.piping_specification_id is a designation that differentiates one piping specification from another (see K.1).

Service limits are specified in piping_specification.service_description. This is simply a narrative explanation or description of the conditions that the piping specification is applicable under. It is not the role of the piping specification to fully explicate the stream conditions. If it is necessary to exchange this information, Stream_design_cases may be defined.

Piping specifications identify certain families of parts that can be used given the service limits. The family of parts is specified with a Plant_item_definition (or, more precisely, a Piping_component that is also a Plant_item_definition) that has a special property. The parameter values for the component may be specified as a range of values.

EXAMPLE   A piping specification may specify a family of 90-degree elbows with a centreline radius of six inches and a nominal size of between one inch and three inches. Everything about the family is same except for the variation in the nominal size.

See L.6 for a complete explanation of value ranges.

L.4 Catalogues items and connectors

As noted in clause 1, this part of ISO 10303 is intended for the exchange of catalogue identifications, not the exchange of the catalogue itself. Catalogues play two roles in this part of ISO 10303:

— partial catalogue information may be exchanged. This information is limited to the identification of the catalogue and the definition of plant items contained in the catalogue. The definition of the plant items in the catalogue is exactly the same as the definition of a plant item as allowed by this part of ISO 10303.

— a plant item may be identified as being from or contained in a particular catalogue;

A catalogue may be an external, predefined catalogue or a user defined catalogue. See K for a complete explanation of how external, predefined catalogues are referenced.

Many design systems also use a catalogue-based approach for connectors. This part of ISO 10303 addresses this requirement with the application object Catalogue_connector. A Catalogue_connector behaves just like a Catalogue_item as described above. The exception is that since a connector (and, therefore, a Catalogue_connector) is a shape_aspect, a Catalogue_connector cannot be individually instanced within an exchange file. A Catalogue_connector definition may be exchanged independently, but any Catalogue_connector instance must be part of a plant item definition. It cannot be part of a plant item instance.

L.5 Pipe lengths

The representation of piping components within a piping design makes a distinction between two kinds of product_definitions: a physical Plant_item_definition and a Physical plant_item_instance. The definition is defined once and instantiated numerous times within a design at different locations to reduce duplication of information. This approach accommodates situations such as the repeated use of a pressure gauge at different locations in a design - one design, many usages.

In most piping designs, individual pieces of straight pipe of a given nominal size and material come in a large variety of lengths. Given the one design-many use approach, this would require that a definition and an instance be created for each pipe of differing length (since the length property of the pipe design shape differs). It is not practical to create Plant_item_definitions for each individual piece because everything about the pipe design is the same except for the length.

The use of this part of ISO 10303 permits two approaches for addressing this situation. The first is that the Plant_item_definition may be defined without specifying a length attribute. In this case, the length of the pipe would be associated with the Plant_item_instance product_definition. In this approach, all the information about the pipe - material, insulation, nominal size (a shape property) - would be associated with the Plant_item_definition product_definition. The shape property of the instance would be represented by (i.e., have representation_items of) the mapped shape of the Plant_item_definition (see discussion of mapped_item) and the parameter end_to_end_length.

The second approach is similar to the first, but specifies descriptive_representation_item with the attribute description assigned a value of "as required", rather than specifying an end_to_end_length. This completely eliminates the need to specify a length and permits the pipe to be "cut to fit" at the plant site.

L.6 Logical connectivity and relationship to physical design

Piping lines and line segments represent the logical connectivity of the process streams and equipment. This is part of a functional design in that the functional capability of the piping system is partially represented by the connectivity of the piping lines and (functional) plant items. The complete representation of the functional capabilities of the piping system is outside the scope of this part of ISO 10303. ISO 10303-221 [3] may be used to represent the complete functionality of the piping system.

The physical design of the piping is associated with the functional design of the piping lines through line_piping_system_component_assignment. This association links an element of the physical design (an instance, not a definition), such as a valve, to a Piping_system_line_segment. This association says "this piping component is on this line". Therefore, one or more piping components may be considered as being "on" a piping line.

Since physical piping components may be connected to form piping runs or piping assemblies, two kinds of connectivity can exist within a usage of this part of ISO 10303: logical connectivity represented by piping system lines and physical connectivity represented by plant item connections. In general, the only points where logical connections correspond to physical connections are where the line terminates at a piece of equipment. This is due to the fact that lines may end at equipment (by definition) and equipment connectors establish connections with piping components. Most physical connections, however, do not correspond to logical connections. Figure L.1 illustrates the relationship between the piping line segments, connectivity between line segments, physical components, and the connectivity between physical components.
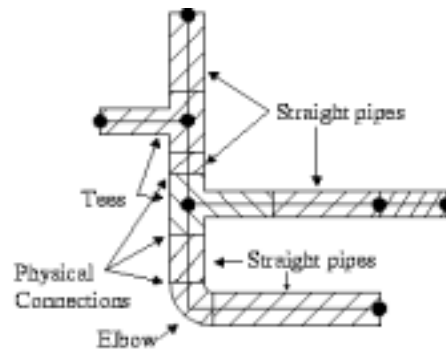

Figure L.1 - Relationship between logical connectivity and physical connectivity

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